NATIONAL SUMMARY



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NATIONAL SUMMARY: BACKGROUND

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This is the first in a series of biennial reports on the *State of Coral Reef Ecosystems of the United States and the Pacific Freely Associated States*. The National Ocean Service led the development, but it is the product of the 38 coauthors, and they are responsible for its content. It is the result of a nationally-coordinated effort by the USCRTF to assess the condition of coral reef ecosystems. The working group was comprised of the USCRTF Governors' Points of Contact, members from all of the USCRTF working groups, and the managers and scientists from participating Federal agencies and U.S. States, Commonwealths, and Territories, and the Pacific Freely Associated States[27].

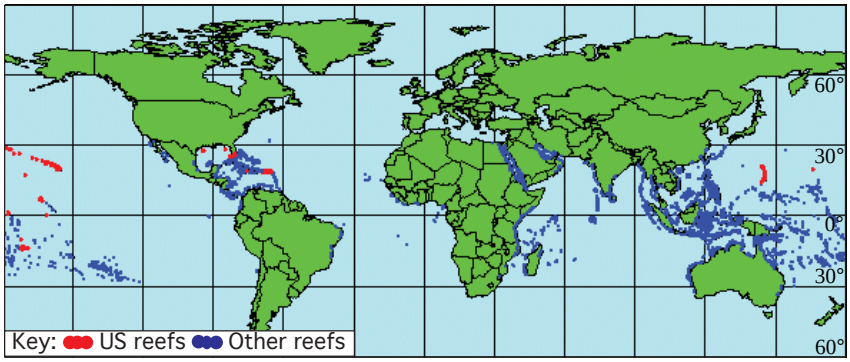
Coral reefs are the most diverse, productive, and economically important habitats found in tropical and semitropical oceans. But little specific scientific information is known about the function, structure, and condition of these ecosystems. Most have yet to be mapped and their biotic resources inventoried. This report is the beginning of gathering consistent, comparable scientific information on all the reefs in the United States and the Freely Associated States, so the condition of these resources can be reliably assessed and conserved.

Coral reefs discussed in this report are found along the Western Atlantic and the continental shelf of the northern Gulf of Mexico, and around Caribbean and Pacific islands (Fig. 25). Western Atlantic and Caribbean shallow-water coral reefs are off the State of Florida, the Commonwealth of Puerto Rico, the Territory of the U.S. Virgin Islands (USVI), and the Navassa Island National Wildlife Refuge. Deeper reefs in the Northern Gulf of Mexico and the Western Atlantic are also covered. Shallow-water reefs off the U.S. Pacific islands are extensive and include the Main and Northwestern Hawaiian Islands, the Territories of American Samoa and Guam, the Commonwealth of the Northern Mariana Islands (CNMI), and seven remote, unincorporated Pacific island areas[28]. Also included in this report are Indo-Pacific reefs around the Freely Associated States. These are among the most biologically diverse coral reef ecosystems in the world.

With their habitat complexity and species richness, coral reefs protect coastlines from storms and are a source of food and recreation for millions of people. Many near-shore coral reef ecosystems are inextricably linked to coastal human populations, water-based activities, and economics. In general, coral reefs provide livelihoods for hundreds of thousands of people in all U.S. affiliated areas. However, human activity is rapidly degrading many near-shore reefs. If coral reef ecosystems are to continue to support abundant, diverse wildlife, as well as the humans that appreciate and depend on them, then they need to be conserved.

The mapping, assessment, monitoring, and other conservation activities presented in this report are the beginning of a comprehensive management strategy to conserve reef resources and to report biennially on the effectiveness of those conservation measures.

Figure 25. Map of coral reefs of the world with U.S. reefs highlighted in red (based on Bryant et al. 1998).



[27] The Freely Associated States were formerly a part of the United States Trust Territory of the Pacific Islands for nearly 40 years following World War II. Three former territories, the Federated States of Micronesia (FSM), Palau, and the Republic of the Marshall Islands (RMI), are now independent nations that retain close association with the United States. Associates of the USCRTF, they requested to be included in this report.

[28] Baker, Howland, Jarvis, Johnston, Kingman, Palmyra, and Wake.

Figure 26. Three types of coral reef formations (Photos: Kip Evans, James Maragos, and the NOS Photo Gallery) .

The rest of this Background discusses topics the managers of coral reefs consider important for the context of statements they make on the condition of corals and other aspects of this valuable aquatic ecosystem. These topics provide background for the classic presentation of sections that follow the Background (i.e., Pressures on the Ecosystem, State, or condition, of the Reefs, and Responses by Agencies to conserve coral reef resources).

Coral Reefs

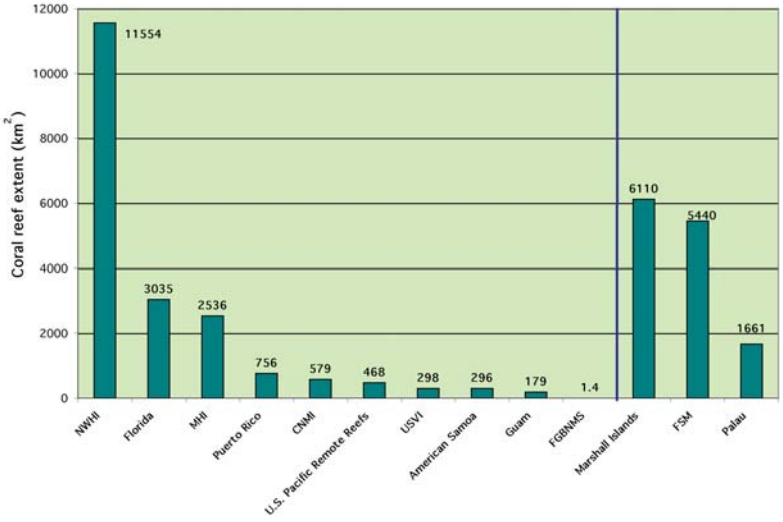
Although deep-sea coral reefs with three-dimensional structure exist in cooler waters, the familiar reefs are in the shallow, clear turquoise-blue waters of tropical and subtropical seas. Reefs generally sit on continental shelves and submerged bases of volcanoes in depths ranging from emergent on low tides to around 150 ft. Shallow-water coral reef development is optimum where sea temperatures are warmest, between 30°N and 30°S, which roughly coincides with the 20°C (68°F) **isotherm** (lines drawn on a map that connect points of equal temperature). Most corals cannot survive temperatures much below 60-65°F (16-18°C) even for a few weeks.

Coral reefs are the largest biological structures on earth, with millions of coral colonies, each made up of thousands of tiny interconnected corals. There are three general types of reefs, with many gradations and variations (Fig. 26)[6]. **Fringing reefs** grow seaward from the rocky shores of islands and continents. **Barrier reefs** are parallel to shorelines of continents and islands and are separated from land by shallow lagoons. Barrier reefs off oceanic islands originate from fringing reefs in a process that is similar to the formation of atolls. **Atolls** are ring- or horseshoe-shaped coral reefs and coral islets surrounding a lagoon. An atoll lagoon is formed when the volcano that is the reef's foundation sinks into the ocean, leaving only the upward-growing reef near sea level. Atoll and barrier reef lagoons are usually connected to the open sea by breaks or passes through the reef, and may hold clusters of isolated **patch reefs** (small reefs that were gradually separated from associated land masses because of island subsidence or rising sea levels).

In addition to shallow reefs, certain corals can also form reef-like structures or **banks** in deeper waters. These structures may play similar roles to shallow reefs, but they have been little studied and are generally not included in this report.

The United States and over 100 other countries claim sovereignty over coral reefs (Birkeland 1997a). Spalding *et al.* (2001) estimated the area covered by shallow coral reefs (less than 200 ft.) worldwide to be 109,800 mi^2 (284,300 km^2). Their estimate of shallow reefs comprises less than 1.2% of the continental shelf area and only 0.9% of the world's oceans. Reefs in sovereign U.S. waters cover an estimated 7,607 mi^2 (19,702.4 km^2, Fig.

Figure 27. Estimated area covered by coral reefs in the United States and Pacific Freely Associated States.



[29] The numbers were computed using informmation from Hunter 1995, FMRI/NOAA 1998, Ault *et al.* 2001, Florida Fish and Wildlife Conservation Commission 2001, Kendall *et al.* 2001, S. Gittings pers. comm., and S. White pers. comm.).

27)[29]. Estimates for the reefs off the Freely Associated States range from 4,479-31,470 mi^2 (11,600-81,500 km^2, Holthus *et al.* 1993, Maragos and Holthus 1999, Spalding *et al.* 2001).

Reef Ecosystems

Ecosystems are composed of biological communities and habitats. **Biological communities** are interacting populations of individual species.

Coral reef ecosystems include the species residing in these habitat types. They also include aquatic residents of associated sand, macroalgae, seagrass, and mangrove habitats. Species have specialized roles (**niches)** within habitats. Basically, organisms can be grouped into three general categories – **planktonic** (floating), **benthic** (bottom dwelling), or **nectonic** (swimming).

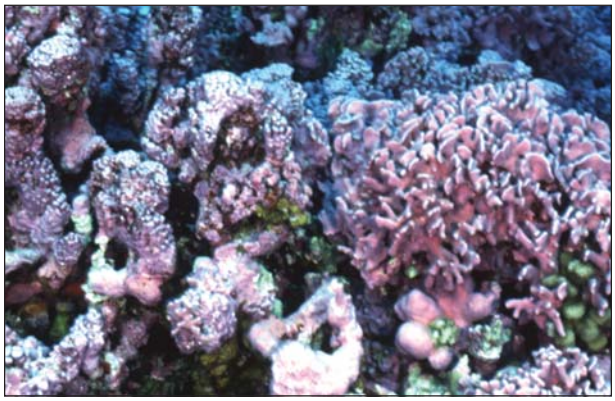


Figure 29. Crustose coralline algae (Photo: James Maragos).

An ecosystem includes all the energy, material/nutrient cycling, and behavioral interactions, linking organisms in a community together and with their environment (Smith 1992). Monitoring components of coral reef ecosystems are key to both understanding their structure and function and wisely managing reef resources. This includes biological factors such as species abundance, size, distributions, diversity, and human-use patterns, along with non-biological factors such as coastal development, sedimentation, and pollution.

Corals and Reef Communities

Corals are ancient animals that evolved into the modern reef-building forms over the last 25 million years (Allen and Steene 1996). They

Figure 28. Coral polyp (Photo: James McVey).

initially appeared as solitary forms in fossils more than 400 million years ago.

The primary building blocks of a reef are polyps of **stony** coral species (also called **scleractinian** or **hermatypic** corals). Each **polyp** is generally **sessile** (attached to the substrate), with a small cylindrical body and prey-capturing tentacles surrounding the opening or mouth (Fig 28). The polyps of stony corals deposit a calcium carbonate skeletal cup around themselves. A coral reef is comprised of millions of these calcified polyps making up individual coral heads. Coral heads are often cemented together by **coralline** (coral-like, calcareous) algae (Fig. 29).

Symbiotic[30] photosynthetic, single-celled algae, called **zooxanthellae** live in the tissues of each stony coral polyp. Reef-building corals cannot live without them. They depend on these microscopic plants for part of their nutrition, so are limited by their symbiont requirements to the maximum depth light penetrates in clear, oceanic waters (around 150 ft). This symbiosis enhances the growth rate and calcium deposition of shallow-water stony corals and contributes toward coral reefs being the most diverse marine ecosystems on earth.

Organisms within coral reef communities can be divided into four main groups.[31] First, the **epibenthos** (sessile organisms, the living substrate) provides the complex structure of the reef itself. These are the coralline and fleshy algae, hard and soft corals, and sponges. Second, **plankton** (tiny floating plants and animals, most are microscopic) provides food for the reef **filter feeders**[32]. Third, the **suprabenthos** are the larger mobile animals that swim over and around the reef. These are the

[30] From **symbiosis**, a term for a beneficial relationship between two organisms. Usually the smaller organism is the **symbiont** and the larger is the **host**.

[31] Modified from the three coral reef components proposed by Reaka-Kudla (1997).

[32] Organisms feed by filtering plankton from the water column. This includes much of the plankton itself, corals, clams, some fish, and baleen whales.

Figure 30. Polychaete worm on a coral reef (Photo: James McVey).

herbivores (those that feed on plants), **corallivores** (those that feed on corals), **carnivores** (those that eat other animals), and **detritivores** (those that feed on dead and decaying matter). Fourth, the **cryptofauna**[33] bores into the substrate and nestles in holes and reef crevices. These bryozoans, sponges, tunicates, and polychaetes further increase reef habitat complexity (Fig. 30).

Coral reefs are unique, biologically diverse systems[34]. Their productivity rivals the tropical rain forests. Although a comprehensive inventory of the biological diversity of coral reef species has yet to be done for the United States and the Pacific Freely Associated States, healthy coral reefs support an abundance of life. Only about 5% of the global coral biota has been described and about 93,000 species of coral reef organisms identified. Based on that, Reaka-Kudla (1997) estimated the 'true number of species on global coral reefs is at least 950,000.' Using another broad assumption, including the premise that only 10% of the organisms on coral reefs have been described, Spalding *et al.* (2001) estimated a global total of 1-3 million species inhabit coral reefs and associated habitats.

Sand, algae, seagrass, and mangrove habitats are integral parts of the reef ecosystem, providing critical nursery areas and essential habitat for reef invertebrates and fish (Fig. 31). Marine organisms rely on the different habitats of the coral ecosystem at different life stages, and the loss or degradation of any of those habitats can have serious effects on the reef. Corals, most fishes, and other reef organisms have planktonic larval stages. Floating with ocean currents, these larvae link different ecosystems, often over large distances. Therefore, the health of a reef partly depends on the condition of ecosystems 'upstream' from which reefs derive **recruits** (juvenile and adult organisms that settle out of the plankton or migrate into the reef community).

A number of reef-associated species have been listed as threatened or endangered under the U.S. Endangered Species Act (Fig. 32). These include all the sea turtles[35], and the Hawaiian monk seal (*Monachus schauindslandi*). The Caribbean monk seal (*M. tropicalis*), also listed as endangered, is probably extinct. Populations of **endemic** species (unique to a specific area, such as a single island) may be especially at risk for extinction[36].

There is also strong international concern that certain coral reef species are threatened or may become threatened through trade. The Convention

Figure 31. Juvenile fish swimming around mangrove roots (Photo: Matt Kendall).

[33] Richter *et al.* (2001) described the cryptofauna as a microcosm within a "swiss-cheese" reef. Inside a reef, there is 2.5-7.5 times the surface area of the outside. These internal areas are crammed with sponges, bacteria, sea squirts, and more. Only about half of the species they encountered were known to science. These authors postulate the cryptofauna filter up to 60% of the plant and animal plankton passing through the reef. The nitrogen and phosphorus they excrete after digesting the plankton fertilizes the corals and allows them to thrive in nutrient-poor waters.

[34] For example, Grassle (1973) reported that a single head of cauliflower coral (*Pocillopora damicornis*) contained 103 species of **polychaetes** (segmented worms with paddle-like appendanges). He also found numerous **decapod crustaceans** (crabs and shrimp), **amphipods** and **isopods** (small shrimp-like crustaceans), **sipunculids** (peanut worms), **oligochaetes** (earthworm-like segmented worms), and **ophiuroids** (brittle stars, a type of starfish).

[35] Green (*Chelonia mydas*), loggerhead (*Caretta caretta*), and olive ridley (*Lepidochelys olivacea*) sea turtles are listed as threatened throughout their range. Hawksbill (*Eretmochelys imbricata*), leatherback (*Dermochelys coriacca*), and Kemps ridley (*Lepidochelys kempii*) are listed as endangered throughout their range.

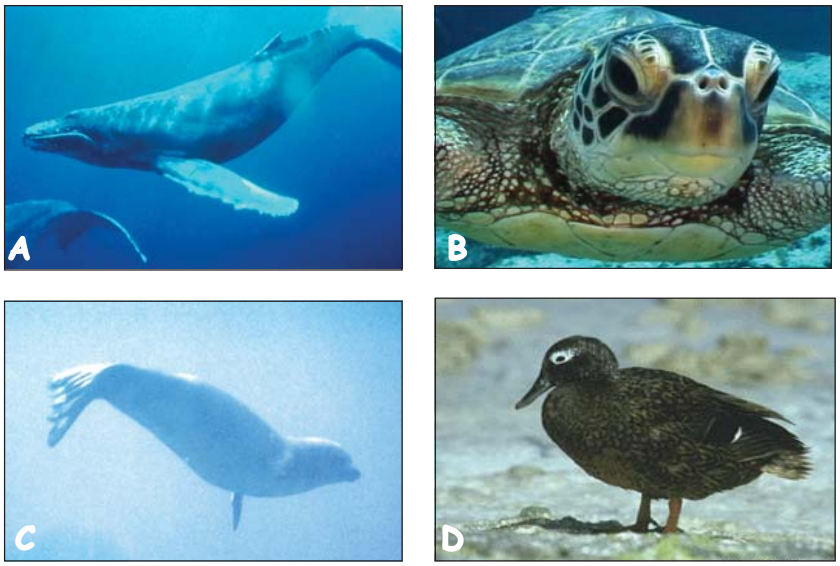


Figure 32. Some examples of Hawaiian species covered under the Endangered Species Act include: (a) the Humpback whale, (b) the green sea turtle, (c) the Hawaiian monk seal, and (d) the Laysan duck (Photos: Joseph Mobely, NMFS, Donna Turgeon and J. Marks).

on the International Trade in Endangered Species of Wild Fauna and Flora (CITES) lists those species. Currently, CITES protection has been extended to a number of reef species, many of which are commercially desirable[37]. CITES also warns that reef sharks are being rapidly depleted because of the global harvest of shark fins.

Cultural Value of Reef Ecosystems

Coral reefs are a significant part of a country's natural heritage. Some of the largest individual coral colonies found on reefs today were thriving centuries before human colonization. Rivaling old growth forests, well-developed reefs reflect thousands of years of growth and development. For centuries, coral reefs have provided sustenance and shoreline protection to indigenous peoples.

Uses of reef resources are woven into the social and cultural fabric of coastal communities. Reefs provide three general types of fishing opportunities: **artisanal** (small village-based fisheries for personal or community consumption), **recreational** (fishing for sport or pleasure), and **commercial** (fishing for commerce through sale, barter, or trade).

Native peoples of the Pacific Islands have a strong cultural and economic dependence on coral reefs and marine resources. Each island or island group had its own language, customs, local government, and a reef tenure system controlled at the village level.

One example of reef tenure systems still operating in Pacific Island rural regions is the traditional harvest system in Hawai'i[38]. Prior to the 1800s, there were social and cultural controls on fishing with a strictly enforced code of conduct (Fig. 33). Harvest management was not based on the amount of fish, but on identifying the specific times and places where fishing could occur. This kept the fishers from disturbing the basic processes and habitats of important food resources (Friedlander *et al.* in press).

Figure 33. A 'hukilau' is a traditional Hawaiian fish gathering method (Photo: Jeff Alexander).

In 1994, the Hawai'i Legislature created a process for designating community-based subsistence fishing areas. These are being created on Moloka'i, Kaua'i, and Hawai'i. One community, residing in the Ho'olehua Hawaiian Homesteads on the northwest coast of Moloka'i, depends on food from the ocean for much of their diet. They prepared a fisheries management plan (Hui Malama o Mo'omomi 1995), proposing to 1) integrate traditional observational methods and science-based techniques;

[36] Endemism is a major concern for some Pacific Islands, particularly so for the State of Hawai'i where about 25% of the reef organisms are endemic, the highest of any coral reef area worldwide (Maragos and Gulko 2002). It is one of the main reasons why many Hawaiian species are endangered or already presumed extinct.

[37] All species of stony corals, black coral (*Antipathes* species), all giant clams (*Tridacna* species), black-lipped pearl oysters (*Pinctada margaritifera*), queen conch (*Strombus gigas*), coconut crab (*Birgus latro*), bumphead parrotfish (*Bolbometopon muricatum*), humphead or Napoleon wrasse (*Cheilinus undulatus*), some groupers, and the above sea turtles species.

[38] This is the traditional spelling. It is used throughout this report. Similar traditional spellings are also used.

	Florida*	Puerto Rico	US Virgin Islands	Flower Gardens	Hawai'i	American Samoa	Guam	Northern Mariana Islands	Marshall Islands	Federated States of Micronesia	Palau
Population (thousands)	5,087	3,809	109	-	7,000	57	155	69	51	133	19
Percent population growth (1990-2000)	23.1%	8.1%	4.2%	-	9.3%	17.7%	15.4%	57.2%	9.9%	22.6%	23.4%
Number of tourists (thousands)	28,820	4,566	2,500	2	11,167	18	1,380	737	5	30	78
Tourist expenditures (millions $$)	1,875	2,388	800	1	10,918	10	936	587	3	3	79

*Table 1. Population and tourism statistics for the U.S. coral reef areas and the Freely Associated States. *This includes only Broward, Dade, Monroe, and Palm Beach Counties.*

2) foster consensus about how fishing would be conducted to restore community values and stewardship; and 3) revitalize a locally-sanctioned code of fishing conduct. Now implemented, it is having an impact. Owing to its isolation and strong community conservation ethics, Friedlander *et al.* (in press) concluded fisheries resources at Mo'omomi are very healthy compared with most areas around the state.

In the past few decades, the lure of balmy climates and beautiful coral reefs has drawn an increasing number of new residents and tourists to nearby seashores. As a result, many of the fragile coral habitats that play an integral role in community dynamics are being affected by human activities with far-reaching consequences. For example, impacts to reef fish communities from overfishing affect not only fishers and their families who depend on fish for their livelihoods, but also residents and tourists who indulge in fresh seafood served at local restaurants, seafood wholesalers and retailers, and exporters of fresh and frozen fish to markets worldwide. Coastal development and reef degradation now threaten their existence.

Economic Value of Reef Ecosystems

Coral reefs are an integral component of local and regional economies. Reefs provide protection from storm wave action, reducing erosion, property damage, and loss of life. They protect highly productive coastal wetland and mangrove habitats, as well as coastal communities, ports, and harbors. Costanza *et al.* (1997) estimated reef habitats globally provide $375 billion each year to humans from living resources (fish and other food) and ecological services (tourism and coastal protection). Cesar (1996) calculated the cost over a 25-year period of destroying 1 km^2 (about 247 acres) of reef ranged between $0.6-2.5 million when the value of fishery, tourism, and protection was considered.

The environment and the economy are inextricably linked, making the management and protection of coral reef resources critical. Coral reefs support a burgeoning coastal population and are a Mecca for tourists, adding millions of seasonal and temporary visitors (Table 1). The U.S. Census (2002) reported over 10.5 million people resided in U.S. coastal counties and islands adjacent to shallow coral reef ecosystems in 2000, with another 203,000 residents living on the islands of the Pacific Freely Associated States. Each year, 45 million visitors[39] are drawn to U.S. seaside and live-aboard accommodations to fish, dive, and otherwise enjoy coral reefs (Fig. 34). Another 113,000 tourists visit the tropical isles of the Pacific Freely Associated States.

Figure 34. Tourists at Sanibel Island Beach, Florida (Photo: South Florida Water Management District).

The only region where a survey and market analysis of reef use has been done is the four-county area of South Florida[40]. When the seasonal and temporary visitors are considered, the region's 5.09 million residents are increased to a **functional daily population**[41] between 5.56-5.92 million, depending on the season (Johns *et al.* 2001). According to those authors, South Florida residents and visitors spent 18.1 million person-days fishing and diving around natural coral reefs as well as viewing them from glass-bottom boats. They used these

[39] This figure was compiled from Stewart 1997, U.S. Office of Insular Affairs 1999, Puerto Rico Planning Board 2000, Ditton and Tahiling 2001, Johns *et al*. 2001, UNESCAP 2002, and the respective regional reports that follow this National Summary.

[40] Broward, Palm Beach, Dade, and Monroe counties.

and other figures to place the annual economic value of South Florida's natural reef ecosystem at nearly $228 million for non-market economic use and at $7.6 billion for its **asset value**[42].

They also calculated that South Florida's natural reefs supported 44,500 jobs, providing a total annual income of $1.2 billion. A similar study was also done for the Flower Gardens National Marine Sanctuary in the Gulf of Mexico off the Texas Coast. Economic studies like these have been recently commissioned for reefs off Hawai'i, American Samoa, and Guam.

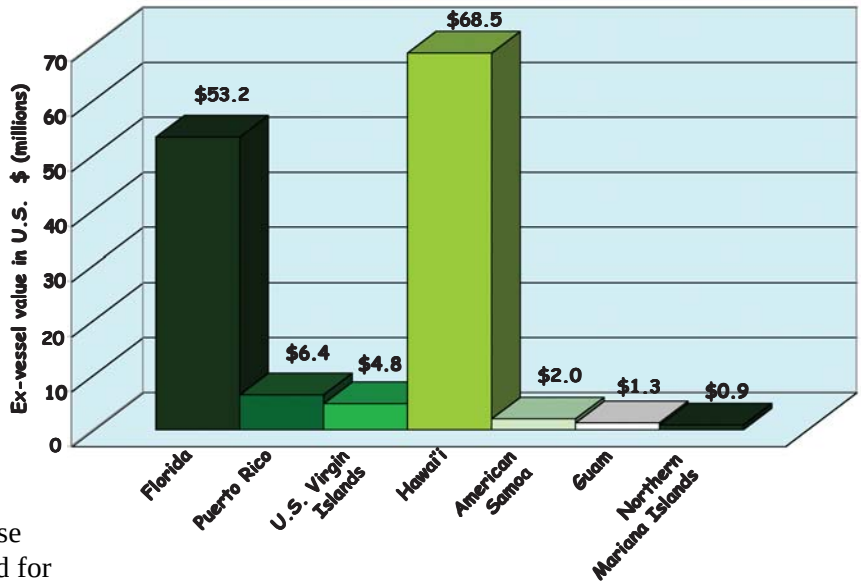


Figure 35. Estimates of the ex-vessel value of commercial fisheries by region.

Comparable data for other reef regions is lacking for a number of reasons. Value of catch comes in gross receipts, dockside value, or is calculated using economic multipliers, none of which can be directly compared. Likewise, States or coastal counties cannot be compared to local beaches or markets. Ultimately, the data may not even be collected. Even without definitive data, in the United States, tourist expenditures in areas with coral reef ecosystems account for at least $17.5 billion[43]. In the Pacific Freely Associated States, tourist expenditures exceed $84.8 million[44].

U.S. coral reefs support commercial **ex-vessel landings** (value of the catch paid to fishermen) of over $137.1 million[45] (Fig. 35). The gross value estimate for commercial fisheries in the Freely Associated States is $109.8 million. Except for South Florida, there are no estimates for the value of recreational fisheries within U.S. coral reefs.

Aside from tourism and fisheries-based sources of income, the Compacts of Free Association with the United States provide additional funds, services, and technical assistance to the Freely Associated States. The governments and some residents of the Marshall Islands also receive lease rents for U.S. use of Kwajalein Atoll as a missile testing facility and monetary compensation for past use of several atolls for nuclear weapons testing.

Bioprospecting (the harvest of biological organisms for medical and other applications) wildlife found on coral reefs offers economic promise. Already, biochemicals produced by many reef species are being used in health care products (e.g., sun blocks), medical procedures (e.g., bone grafts), and pharmaceuticals for treating viral infections and other medical conditions. Ongoing medical research indicates that other biochemicals extracted from reef-associated species may offer treatments for leukemia, skin cancer, and other diseases (Birkeland 1997a). There are concerns among coral reef managers that it may be a new threat to U.S. coral reef ecosystems, so they caution that bioprospecting must be carefully managed.

Global Concerns

U.S. coral reefs share many problems with reefs around the world. In 2002, the world population was 6.2 billion people (U.S. Bureau of the Census 2002) with almost 0.5 billion people living within 60 mi of some coral reef (Bryant *et al.* 1998, Henrichsen 1999). Coastal residents and the influx of tourists place increasing demands on these complex and fragile ecosystems. Some can no longer

[41] All the people in a given area on a given day that demand local services (e.g., fresh water, sewage and solid waste disposal, electricity, and transportation).
[42] The amount someone would pay to purchase the reefs and receive the $228 million in income annually.
[43] Compiled from regional figures from Stewart 1997, U.S. Office of Insular Affairs 1999, Hawai'i DBEDT 2000, Puerto Rico Planning Board 2000, Johns *et al*. 2001, UNESCAP 2002, B. Ditton pers. comm.
[44] From U.S. Office of Insular Affairs statistics.
[45] Computed from information in Caribbean Fisheries Management Council (1998), Leeworthy (2001), and NMFS (2001).

Figure 36. Coral reefs in Bali, Indonesia are some of the world's most diverse reefs, as well as the most threatened (Photo: Jim Hendee).

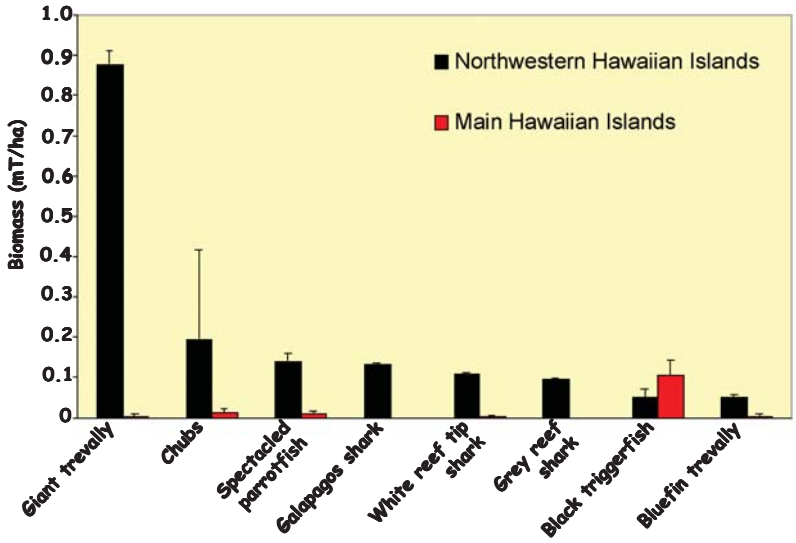
sustain such pressures. Given the declines in fisheries worldwide (Fig. 36), harvesting fish using unsustainable practices (e.g., dynamiting, poisons, overfishing) is destroying marine fisheries and coastal ecosystems (FAO 1995, Fig. 37). Sixty percent of commercial stocks are either fully harvested to the quota or overfished. This has direct and indirect implications for coral reef ecosystems and can be illustrated with the fisheries of the Hawaiian Islands.

The Northwestern Hawaiian Islands (NWHI) are relatively pristine and have little fishing pressure, while the Main Hawaiian Islands (MHI) have some of the densest populated islands in the Pacific[46] with attendant heavy fishing of coral reef species. As a result, scientists have found the NWHI coral reef fish community to be dominated by carnivores that are larger and more abundant than the fish community off the populated areas of the MHI (Okamoto and Kawamoto 1980, Hobson 1984, Parrish *et al.* 1985, Friedlander and DeMartini 2002). Those authors reported one jack and three sharks[47] comprised 94% of the predator biomass at 106 coral reef stations in the NWHI, but were all but missing in the MHI (Fig. 38). Collectively, one parrotfish and two species of chubs[48] contributed nearly 50% of the herbivore **biomass**[49] in the NWHI, but were less than 7% of the biomass in the MHI. Only the black triggerfish (*Melichthys niger*), which is rarely targeted by fishers in the MHI, had greater relative abundance and biomass than that of the NWHI. Most likely these differences are from the near removal (**overfishing**) of top predators and heavy exploitation of lower trophic levels in the MHI compared to the largely unfished NWHI.

Figure 37. Cyanide fishing is an unsustainable practice and a serious concern for reefs in South East Asia (Photo: International Marinelife Alliance).

Overfishing is only part of the world-wide degradation of reefs over the past decade. Bryant *et al.* (1998) estimated 36% of all reefs were potentially threatened by overexploitation, 30% by coastal development, 22% by inland pollution and erosion, and 12% by marine pollution. Combined, 58% of the world's reefs face medium or high risk of degradation from human activities. This is similar to other estimates. Wilkinson (2000) found 66% of coral reefs are degra-ded globally. The Global Coral Reef Monitoring Network's *Status of Coral Reefs of the World 2000* (Wilkinson 2000) estimated that before 1998, about 11% of the world's reefs may already be beyond recovery from **anthropogenic** (human-induced) impacts (Fig. 39). The extensive climate-

Figure 38. Biomass of dominant fish species in the Main and the Northwestern Hawaiian Islands (Source: Friedlander and DeMartini in press).



[46] Hawai'i and O'ahu are home to most of the population of the state.

[47] The giant trevally (*Caranx ignobilis*) and Galapagos, grey reef, and whitetip reef sharks (*Carcharhinus galapagensis, C. amblyrhynchos*, and *Triaenodon obesus*)

related mortality of corals in 1997-1998[50] destroyed an additional 16% of the world's reefs, with the worst impacts in the Indian Ocean (Wilkinson 2000). A detailed discussion of the impacts of an-thropogenic and natural pressures on reef ecosystems will be presented in Environmental Pressures.

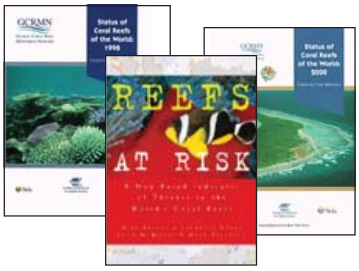


Figure 39. Reports on world-wide coral reef degradation.

Large marine vertebrates – whales, manatees, turtles, groupers, and sharks – have been harvested systematically by humans over the past 500 years and are now effectively absent from most coastal ecosystems (National Research Council 1995, Jackson *et al.* 2001, Pitcher 2001, Fig. 40). Populations of species important to many marine ecosystems are now so low they cannot exert their former ecological role; some are near extinction (Dayton 1998). The indirect effects are unknown because no baseline data exist for comparison (Dayton *et al.* 1998). Modern studies of marine ecosystems began long after enormous changes in these systems had occurred (Jackson 1997, Jackson *et al.* 2001), and the 'shifting baseline syndrome' (Pauly 1995, Sheppard 1995) makes it difficult to determine what constitutes a natural ecosystem. Because of this, it is also difficult to determine how to properly manage these ecosystems.

Predator-dominated coral reef ecosystems may well be the natural state (Fig. 41), but predaceous species are the most susceptible to, and most rapidly removed by human activities. Thus, the natural state is difficult to observe. The exception is the NWHI because limited human population and fishing activity means minimal human impact (Friedlander and DeMartini in press). These reefs are among the few remaining large, intact, predator-dominated reef ecosystems in the world.

Figure 40. The populations of manatees have been reduced by a long history of harvesting (Photo: Laurel Canty-Ehrlich, FKNMS).

The NWHI is one of the few reef ecosystems that is sufficiently pristine to study how unaltered sys-tems are structured, how they function, and how they can be effectively preserved (Friedlander and DeMartini in press). They offer a chance to deter-mine what could occur if larger and more effec-tive no-take marine protected areas were used other places.

Figure 41. Predator-dominated coral reef ecosystem in the Northwestern Hawaiian Islands (Photo: NOW-RAMP Expedition/Bishop Museum).

[48] The chubs (*Kyphosus bigibbus* and *K. vaigiensis*) and the endemic spectacled parrotfish (*Chlorurus perspicillatus*).
[49] Biomass is the weight or mass of a taxonomic group (i.e., species) in a given area (e.g., sample transect, habitat).
[50] See the section on Climate Change and Coral Bleaching for a full discussion of this event.

NATIONAL SUMMARY